CONTROL OF LEAF ROLL VIRUS IN POTATOES

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Summary

Experiments to control potato leaf roll virus by the use of insecticides and by altering the planting date were carried out in each of the years 1959 to 1962. Leaf roll counts were done on samples regrown in the following year. In the 1960, 1961 and 1962 trials, the average incidence of leaf roll in plots sprayed with demeton-S-methyl (3 sprays) was 4%, in plots sprayed with DDT it was 9%, and in the untreated plots it was 21%. Altering the planting date (and so missing the main aphid flight) achieved a similar result. The average incidence in plots planted early October was 19%, early November 2.5%, and early December 2.5%.

Trials with granular insecticides (applied in the furrow at planting) were begun in 1963 and have given similar results. They are a much more convenient method of achieving aphid and virus control in potatoes and are likely to be widely adopted.

INTRODUCTION

POTATOES are affected by three main virus diseases, namely, mild mosaic, severe mosaic, and leaf roll. Transmission of these viruses from diseased to healthy plants is either mechanically through sap transfer (mild and severe mosaics) or by aphids (severe mosaic and leaf roll). Control of these diseases can be achieved by breeding resistant varieties or by preventing transmission from taking place.

In New Zealand, potato varieties are either resistant (by hypersensitivity) to mild mosaic or else they are completely infected with this virus, in which case it reduces yields by 10 to 20%. Severe mosaic is prevalent in only a few varieties such as Dakota, Epicure, Glen Ilam, Jersey Bennes and King Edward, most other varieties being resistant. Leaf roll virus is the most important potato virus disease and is a problem in the varieties Ilam Hardy, Sebago, Rua and Aucklander Short Top. It is the cause of degeneration or break-down of these varieties, and the main reason for the rejection of lines of these varieties from seed potato certification. There is an urgent need to prevent this break-down so that table potato growers can keep their own seed for longer periods than at present, and that greater amounts of high-quality and reliable certified seed can become available. As this virus is transmitted only by aphids, control of aphids may achieve control of virus spread.

There are three species of aphids commonly found on potatoes in New Zealand, namely *Myzus persicae* (Sulz.), *Aulacorthum solani* (Kltb.) and *Macrosiphum euphorbiae* (Thom.). However, only *M. persicae* is an efficient vector (Day, 1955) and there appears to be a correlation between its abundance and the rapidity of break-down of seed potatoes.

Leaf roll virus is known as a persistent virus — that is, once infected aphids remain infected. Aphids take a long time (24 to 48 hours) to pick up the virus from a diseased plant and an equally long period is needed for the aphids to infect a healthy plant. In this period of acquisition and transfer of the virus to healthy plants, the aphids can be killed with insecticides and transmission prevented. In potato crops, most spread of leaf roll virus usually takes place at emergence or shortly thereafter, when the plants are readily infested by aphids and are most susceptible to infection with leaf roll virus. Winged potato aphids usually arrive in crops free of virus, and spread occurs from diseased to healthy plants only within the crop. This contrasts markedly with the situation in peas and spring wheat where aphids, on arrival, are fully infective with pea top yellows and barley yellow dwarf viruses, respectively, and spread is into the crop from diseased plants in the vicinity.

As trials in North America (Fernow and Kerr, 1953) and in Europe (Broadbent *et al.*, 1956) have indicated that leaf roll spread can be controlled through using insecticides, experiments for aphid and virus control in potatoes were commenced in 1959. Another approach is to alter the planting data so that the young potato plants miss the main aphid flights, and this also has been investigated.

METHODS

The insecticide spray and late planting trials 1959 to 1962 were of randomized plots, 5 or 6 replications per treatment, and using the potato variety Ilam Hardy. Each plot was 7 rows wide × 20 plants long and they were surrounded by either 1 row of Dakota buffer plants (1959) or by 3 rows (1960–62). Two leaf roll infected tubers were planted in the middle row of each plot. Either five (1959) or three (1960–62) sprays were applied, the first being at 90% emergence of the crop, the second 10 to 12 days later, and the others at 14-day intervals. At harvest, samples were dug from plants in the same row as the infectors and from rows on either side, one tuber being taken from each plant. Samples were regrown the following season and leaf roll counts made.

Granules were applied in the furrow at planting (in combination with fertilizer) to ¼ acre blocks (Trials I and II) or to 6 row × 2½ chain plots (Trial III, 2 replications). Infectors were planted in Trial III (rows 3 and 4) and samples were dug from the same row as the infectors (within row spread) or from adjacent rows (between row spread).

In the lines of seed potatoes used for planting the spray and late-planting trials, the initial percentage infection with leaf roll virus varied between 1.5% and 3%, except in the November planting, 1959, when it was less than 0.5%. In the granule trials, the initial infection with leaf roll was: Trial I, 0.5%; Trial II, 3%; and Trial III, 2.6%.

RESULTS

Table 1 shows that demeton-S-methyl sprays can effectively reduce the spread of potato leaf roll virus. (All rates are in a.i. per acre except where stated.) Three sprays (commencing at 90% emergence) were just as effective as five sprays. DDT sprays also had a considerable effect on leaf roll spread. In 1959, dimethoate was mixed with charcoal and then with superphosphate and applied in the furrow at planting. This treatment also was effective. Aphid counts at seven weeks after planting and seven days after the second spray (Table 1) showed that both dimethoate and demeton-S-methyl were controlling aphids.

TABLE 1: CONTROL OF POTATO LEAF ROLL VIRUS SPREAD IN THE VARIETY ILAM HARDY BY THE USE OF INSECTICIDES

Trial I 1959–60. Planted October 8, 1959			
Treatment	*Incidence of Leaf Roll*	*Aphid Count of 100 Leaves Nov. 25, 1959*	
		Apterae	*Alates*
Demeton-S-methyl — 4 oz — 5 sprays*	9/200† – 4.5%	4	8
Dimethoate — in soil, 0.35 g per tuber	7/200 — 3.5%	33	16
Untreated	24/200 — 12.0%	272	17

* Plants were sprayed on November 8, 18 and 27, December 11 and 23, 1959.

	Incidence of Leaf Roll		
Treatment	*Trial II 1960–1*	*Trial III 1961–2*	*Trial IV 1962–3*
Demeton S-methyl 3 oz — 3 sprays	9/250 — 3.6%	12/250 — 4.8%	10/250 — 4.0%
DDT — 2 lb — 3 sprays	29/250 — 11.6%	23/250 — 9.2%	16/250 — 6.4%
Untreated	59/250 — 23.6%	73/250 — 29.2%	26/250 — 10.1%

† Numerator: Number of plants with leaf roll.
Denominator: Total number of sampled plants, one tuber per plant.
Five replications per treatment in all trials.

Table 2 shows that the spread of leaf roll virus can be prevented by late planting. This is because the spring aphid flights of potato aphids have almost ceased by the time plants in late-planted plots are emerging. In 1959 and 1961, spring flights had ceased by the end of December, and in 1960 and 1962 they ceased early December. Yield figures from the different planting dates were, in 1959: first planting, 11.2 tons per acre; second, 9.7 tons; and third, 6.2 tons. The figures respectively for 1962 were 16.7, 15.0 and 9.7 tons per acre.

TABLE 2: CONTROL OF POTATO LEAF ROLL VIRUS SPREAD IN THE VARIETY ILAM HARDY BY LATE PLANTING

Date of Planting	*Incidence of Leaf Roll*	*Date of Planting*	*Leaf Roll Incidence of*
	Trial I 1959–60		*Trial II 1960–1*
Oct. 8, 1959	24/200* – 12.0%	Oct. 4, 1960	59/250 — 23.6%
Oct. 28, 1959	30/240 — 12.5%	Nov. 9, 1960	4/250 — 1.6%
Nov. 26, 1959	0/240 — 0%	Dec. 14, 1960	3/250 — 1.2%
	Trial III 1961–2		*Trial IV 1962–3*
Oct. 11, 1961	73/250 — 29.2%	Oct. 16, 1962	26/250 — 10.1%
Nov. 7, 1961	8/250 — 3.2%	Nov. 13, 1962	7/250 — 2.8%
Dec. 8, 1961	10/250 — 4.0%	Dec. 10, 1962	6/250 — 2.4%

* Numerator: Number of plants with leaf roll.
Denominator: Total number of sampled plants, one tuber per plant.
In Trial I, there were five replications in the first planting and six in the other two. In Trials II, III and IV, there were five replications per planting.

Treatment with granular insecticides effectively reduced the spread of leaf roll virus (Table 3), especially in the varieties Sebago (Trial II) and Ilam Hardy (Trial III). In Trial I, there was very little spread of leaf roll even though a high population of aphids was present on the untreated plants. From this and other observations, Katahdin appears to be resistant to infection with leaf roll virus. All of the granular insecticides (except B77) gave good control of aphids (Smith *et al.*, 1964, Table 4).

TABE 3: CONTROL OF POTATO LEAF ROLL VIRUS BY THE USE OF GRANULAR INSECTICIDES APPLIED IN THE FURROW AT PLANTING

Treatment	*Rate (lb)*	*Trial I, 1963–4, at Crafts, Rata var. Katahdin Leaf Roll Counts 1964–5*		*Trial II, 1963–4, at Boswell, Rata var. Sebago Leaf Roll Counts 1964–5*	
Untreated	0	4/600*	0.7%	65/600	10.8%
Disulfoton	0.5	6/600	1.0%	42/600	7.0%
Disulfoton	1.0	5/600	0.8%	16/600	2.7%
Disulfoton	2.0	5/600	0.8%	11/600	1.8%

Treatment	*Rate (lb)*	*Trial III, 1963–4, at Crop Research Division, Lincoln Variety — Ilam Hardy Leaf Roll Counts 1964–5* Spread within Rows		Spread between Rows		*Average Percent.*
Untreated	0	32/190	17.0%	33/230	14.3%	15.7
Menazon Spray (on Tubers)	1.5	6/220	2.5%	8/460	1.7%	2.1
Menazon	1.5	13/200	6.5%	14/460	3.0%	4.8
B77 ("Fitios")	1.5	29/200	14.5%	18/460	3.9%	9.2
Disulfoton	1.5	3/200	1.5%	15/460	3.3%	2.4

* Numerator: Number of plants with leaf roll.
Denominator: Total number of plants.
Trial III: Two replications per treatment.

In Table 3, Trial III, more spread appears to have occurred within rows, than between rows. The granular insecticides (B77 and menazon) seemed to be effective in controlling spread between rows but not within rows. This may indicate that spread between rows is by winged aphids, whereas spread within rows is by wingless aphids. In the spray trials in untreated plots, more spread occurred in the row containing infectors than between rows. This is presumably due to the fact that the foliage of plants is in contact sooner within rows than between rows and aphid movement can take place along the rows more readily.

Field trials for leaf roll control in potatoes were, in 1963–4, at Milford, Christchurch and Rangiora, using three sprays of demeton-S-methyl. Leaf roll counts in 1964–5 gave the following figures for treated and untreated areas, respectively: Milford, 3.5 *v.* 7.0%, variety Sebago; Christchurch, 6 *v.* 23%, variety Ilam Hardy; and Rangiora 1 *v.* 3.7%, variety Ilam Hardy.

Residue analyses have been done on tubers from trials with granular insecticides conducted in 1964–5. Plants were sampled at 10 weeks after planting, and thereafter every three weeks. Interim results indicate that residues are very low, and materials are safe from this point of view.

DISCUSSION

Flights of potato aphids in Canterbury (Close and Lamb, 1960; A. D. Lowe, pers. comm.) are characterized by a peak in the October-November period, very few are flying in January and February, and there is another peak in March-April. Potatoes are usually planted in October and are emerging in early November when they are immediately colonized by winged aphids, and in this period much spread of leaf roll virus can occur. Thus the plants need to be protected from aphid attack as soon as possible, or planting should be delayed so that plants emerge after aphid flights have ceased.

Spread of potato leaf roll virus can be prevented in Canterbury by controlling aphids on potatoes by any of three methods: (1) Insecticide sprays — three applications beginning at 90% emergence, (2) Granular insecticides applied in the furrow at planting, (3) Late-planting. Of these methods, it is likely that the use of granules in the furrow will be most widely adopted. It is very convenient, it fits in with a farming operation (planting), and little extra work is involved. Granules must be metered into the furrow through applicators which are attached to potato planters. Good aphid control is obtained for six to eight weeks after emergence. The disadvantages of sprays are that it is an extra farming operation, much tractor damage of the crop can occur, and spraying may not be possible at the correct time. Late planting is a satisfactory method in Canterbury and is practised by some growers. Naturally lower yields are obtained, but if only seed is needed then such yields may be acceptable. A proportion of a crop, if sown late, could provide seed for the following season. An additional advantage of late planting is that it may prevent spread of severe mosaic which is difficult to control with insecticides. As aphid flight patterns are not available for other areas of New Zealand (except Auckland, one year's results; Lamb, 1958), it is not known whether late planting will be generally applicable. Roguing of diseased plants as soon as they are detectable is an important and necessary adjunct to any of the methods for virus control in potatoes.

Further trials are in progress to determine the relative effectiveness of different granular insecticides in controlling leaf roll but results will not be available until the 1965–6 season.

Residue analyses of tuber samples have been done by the Chemistry Division, D.S.I.R., and these indicate that residues are at a low level and not likely to be a problem.

The cost of using granular insecticides on potato crops is likely to be about £5 per acre. However, this cost will be fully compensated for by the increased yields or decreased production costs which will occur because: (1) Better quality certified seed will be available, (2) Seed quality can be maintained, in areas where aphids are prevalent, so that low-cost seed can be used for subsequent crops, (3) Aphid damage will be reduced, and (4) There will be no transport costs for farm-saved seed. It is difficult to place a figure on the savings that will result, but it is conservatively estimated that they will be £400,000 annually.

Ultimately, potato viruses will be controlled by breeding resistant varieties. Suitable hybrids are now available at Crop Research Division immune to mild and severe mosaics but not to leaf roll. The development of varieties resistant to leaf roll will take several years yet. However, the use of chemicals to protect plants against this virus will be satisfactory as an interim control measure.

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